Estimating the abundance and distribution of snow crab (*Chionoecetes opilio*) off Cape Breton Island using video camera transects: a complementary technique to the bottom trawl survey

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ESTIMATING THE ABUNDANCE AND DISTRIBUTION OF SNOW CRAB (*CHIONOECETES OPILIO*) OFF CAPE BRETON ISLAND USING VIDEO CAMERA TRANSECTS: A COMPLEMENTARY TECHNIQUE TO THE BOTTOM TRAWL SURVEY

by

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ABSTRACT

A fishery for snow crab (*Chionoecetes opilio*) has occurred on the east coast of Nova Scotia since the late 1970's. A biomass index was introduced for the 2000 fishing season based on three years of data collected by the Department of Fisheries and Oceans using a *Nephrops* trawl net. Because of uncertainties related to trawl behaviour on hard bottoms and the seasonal movements of snow crab in these areas, a simultaneous trawl, video, and trap study was initiated in 2003 in the Glace Bay Hole area of Sydney Bight to complement the trawl survey data. A video camera was attached to a sled and pulled along the ocean floor at approximately 1.5 nautical miles per hour. The video feed was recorded along with the latitude and longitude and later viewed to create a log of the identified organisms. Sixteen traps were set in and around the study region to qualify the crabs viewed in the video survey. Abundance and biomass indices were calculated and mapped using a geostatistical method called kriging. The trawl survey study area covered a 3,388 km^2 surface with an estimated biomass of 2,527 metric tonnes (mt). The video survey study area covered 2,366 km^2 with an estimated biomass of 2,882 mt. The total biomass within the study areas covered by the trawl and video surveys, accounting for the common area, was estimated at 4,332 mt, 40% more than those of the trawl survey. The video survey appears to be an effective means of assessing commercial snow crab and their habitat. Gear selection is an essential part of any study; the best strategy for a snow crab survey in the Glace Bay Hole may be a combination of the conventional *Nephrops* trawl, video camera, and trap surveys, which may allow an increase in the accuracy of the snow crab stock assessment.

RÉSUMÉ

Une pêcherie pour le crabe des neiges (*Chionoecetes opilio*) se déroule sur la côte est de la Nouvelle-Écosse depuis la fin des années 1970. Un indice de la biomasse a été introduit lors de la saison de pêche de 2000 qui était basé sur trois années de données recueillies par le Ministère des Pêches et des Océans en utilisant un chalut *Nephrops*. À cause de l'incertitude associée au fonctionnement du chalut sur les fonds durs, et aux mouvements saisonniers du crabe des neiges dans ces régions, une étude simultanée au chalut, vidéo et casiers a été initiée en 2003 dans la région de Glace Bay Hole du Sydney Bight afin de complémenter les données du relevé au chalut. Une caméra vidéo était attachée sur un traîneau et tirée sur le fond océanique à une vitesse approximative de 1.5 mile nautique. La vidéo était enregistrée avec latitude et longitude, et visionnée plus tard pour créer un registre des organismes identifiés. Seize casiers ont été pêchés dans la région d'étude afin de qualifier les crabes observés durant le relevé vidéo. L'abondance et l'indice de biomasse ont été

calculés et cartographiés en utilisant une méthode géostatistique appelée krigeage. L'air d'étude du relevé au chalut couvrait une surface de 3,388 km^2 et avait une biomasse estimée de 2,527 tonnes métriques (mt). L'air d'étude du relevé à la vidéo couvrait une surface de 2,366 km^2 et avait une biomasse estimée de 2,882 mt. La biomasse totale dans l'air d'étude couvert par les relevés au chalut et vidéo, en tenant compte de la région commune au deux relevés, a été estimée à 4,332 mt, soit 40% de plus que l'estimé du relevé au chalut. Un relevé vidéo semble être un moyen efficace d'évaluer le crabe des neiges commercial et son habitat. La sélection de l'équipement étant une partie essentielle de toutes études, la meilleure stratégie pour le relevé du crabe des neiges dans la région de Glace Bay Hole est peut-être une combinaison des relevés au chalut *Nephrops* conventionnel, de la caméra vidéo et aux casiers, permettant ainsi d'augmenter la précision de l'évaluation du stock de crabe des neiges.

1.0. INTRODUCTION

Effective methods for estimating fish distribution, abundance and associated population size structures are critical for assessing populations and recruitment patterns (Spencer et al., 2005). In fact, these are among the most fundamental and basic aspects of fisheries research and subsequent management initiatives (Morrison and Carbine, 2006).

The snow crab (*Chionoecetes opilio*) fishery off eastern Nova Scotia (ENS) began in the late 1970's. Until 1997, it was a competitive fishery whose management was based solely on effort controls. Adult snow crab are generally found on sandy and/or muddy substrate at depths of 20 to 310 m (Squires, 1990) in temperatures ranging from -1°C to 4.5°C (Drinkwater et al., 2003), where they are known to partially or completely bury themselves in soft sediment (Miller, 1975). Thus, a Bigouden *Nephrops* trawl, originally developed for Norway lobster (*Nephrops norvegicus*) and designed to dig into the soft bottom sediment, has been the conventional gear used to survey snow crab in Canada's maritime provinces (Conan et al., 1994). In 1997, the Department of Fisheries and Oceans (DFO) introduced a trawl survey in eastern Nova Scotia that covered all trawlable bottoms (i.e. sand, mud, gravel) on traditional and non-traditional snow crab fishing grounds. The survey was established to improve the management of the snow crab stocks and to assess the size of the population. The stock assessment resulting from this trawl survey showed that the population was much larger than previously estimated, which permitted a 6-fold increase in total allowable catch without putting pressure on the snow crab stock (Biron et al., 2004).

However, because of the complex topography in this area (Davis and Brown, 1997), there were doubts regarding the accuracy of the trawl survey population estimates within certain areas, specifically Sydney Bight, Misaine Bank and south-western Nova Scotia (Fig. 1). These areas are effectively non-trawlable, owing to the hardness of the substrate, and cover a significant portion of the snow crab habitat in the eastern Nova Scotia area (Biron et al., 2004). For example, the Sydney Bight snow crab management areas (CFAs 20 to 22) (Fig. 2) have the particularity of being composed of approximately 25% hard and non-trawlable, shallow bottom between 0 to 90 m depth range, 35% soft bottom between 90 to 200 m depth range, which includes the main fishing grounds, and 40% the deeper, warmer, soft-bottomed Laurentian slope and channel area at the depth range of 200 to 450 m (Biron et al. 2004).

In May 2001, extra tows were added to the annual snow crab trawl survey in the Laurentian Channel, extending the surveyed area to depths up to 450 m, but no recruitment or adult snow crabs were found (Biron et al., 2002). During the May 2001 survey, the coldest bottom temperatures were found on the shallow, hard bottom of Smokey and St. Ann's Bank (-0.5°C to 0.75°C), the warmest temperatures were found in the deeper Laurentian slope and channel (4°C to 6°C), while the remaining intermediate soft bottom had temperatures ranging between 1°C and 3°C (Biron et al., 2002).

In addition, the timing of the fishery in areas, such as the Glace Bay Hole (GBH) fishing grounds in Sydney Bight, seems to be of great importance given

the anecdotal evidence that showed a lack of large commercial crab immediately prior to the fishery (Biron et al., 2004). The temperature information and lack of large commercial crab immediately prior to the fishery suggest that snow crab may be distributed near shore or in other non-trawlable areas during the traditional survey, which takes place before the fishery begins.

An experiment was therefore developed around one of the main fishing grounds of the Sydney Bight to assess the distribution, biomass and other biological parameters of the snow crab population over a large area of soft and hard bottoms simultaneously by means of *Nephrops* trawl, video camera and trap surveys. The focus of this study was on the GBH: a relatively small area of muddy bottom, bound to the north, south and west by the shallow hard bottom of Smokey and St. Ann's Banks, and to the east by the deeper, warmer water of the Laurentian Channel (Fig. 2). This experiment was not strictly designed to compare the video camera survey with the trawl survey, but rather to estimate the abundance and distribution of snow crab over both soft (trawlable) and hard (untrawlable) bottoms, and therefore complement the assessment conducted with the conventional *Nephrops* trawl survey.

2.0. MATERIALS AND METHODS

TRAWL SAMPLING

Twenty bottom trawl stations were sampled on June 25 and 26, 2003 with the chartered 65 foot commercial fishing vessel, the Marco Michel, over the trawlable bottom of the study area (Fig. 3). A Bigouden *Nephrops* trawl was used (20 m head line, 27.3 m foot rope mounted with a 3.2 m long, 8 mm galvanised chain, and a mesh size of 80 mm in the wings, 60 mm in the belly and 40 mm in the cod-end (Conan et al., 1994). The locations of the trawl stations were determined in 1995 using a systematic random sampling design and remained fixed for future surveys. During the initial sampling, one location was randomly chosen within each 10 minute latitude/longitude grid. The duration of each tow varied between 4 to 6 minutes at an average speed of two knots depending on the depth, current and sediment. The onboard starting point for each tow was based on the locking of the winch drums after a predetermined amount of warp was released (3 times the water depth). The tow ended as soon as the winches began hauling the trawl net. In cases where abnormal net behaviour or damage occurred, the tow was repeated in the same location. Net behaviour, including the trawl width, was recorded every four seconds using NetMind® acoustic sensors and a Minilog® data logger was used to record temperature and depth. A DGPS system recorded the position every second and was used to calculate the speed of the vessel and the trawl. These data were combined with the trawl width data to yield a swept area estimate (Surette, unpublished data).

The catch of each tow was photographed after being released on the deck. Measurements of the carapace width (CW), chela height (CH), carapace hardness (Ha) and carapace condition (CC) were recorded for all male crabs, while measurements of the CW and the width of the fifth abdominal segment (AW) were recorded for females. The catch composition was separated by

carapace hardness (hard or soft), size and morphometric maturity. New-soft (CC-1) and clean crab (CC-2) with durometer readings <68 were considered as post-moult soft-shelled crabs (Moriyasu et al., 1998). The terminology of male maturity phase follows Sainte-Marie et al. (1995). Adult (terminal moult) and adolescent (non-terminal moult) males were identified based on the following discriminant function, assigning individuals to the correct groups in 99% of cases (for adult males: $Y > 0$), calculated for ENS male snow crab (Biron et al., 1999):

$$Y = \ln(CH) - 1.28 \ln(CW) + 2.86$$

VIDEO CAMERA SURVEY

Twenty-six video camera stations were sampled between June 17 and 26, 2003 with the 60 foot research vessel CCGC Opilio (Fig. 3). The bottom at each station was filmed using a video camera attached to a sled (Fig. 4). Each station consisted of two intersecting transects in the form of an 'X'. This allowed the sediment type to be identified at the point where the two tows crossed; soft sediment if the first track was clearly visible and hard sediment if no track was seen. The duration of the tow in each transect varied from 15 to 20 minutes at an average speed of 1.5 knots. Two fixed lasers projected a 15 cm wide reference length on the ground at all times and the average viewable width was approximately 1.2 m. DGPS information was fed into the video display. Start and end coordinates were recorded at the moment of touch-down and lift-off. Positions were then corrected according to the amount of warp released for each tow. The position was taken every 20 seconds and all species observed were recorded. Observed snow crabs were separated into 3 categories: commercial-sized males ≥ 95 mm CW, undersized crabs (adults, adolescents, males and females between 36 and 94 mm CW) and immature crabs ≤ 35 mm CW.

TRAP SURVEY

A trap survey was conducted after the completion of the trawl and video camera surveys to provide an indication of the size and population structure of the crab observed during the video camera survey. Sixteen modified conical traps (i.e. mesh size of 40 mm) were set near or at the same positions as the video camera stations (one trap/station) between June 26 and July 2, 2003 (Fig. 3). The total number of crab, the position and depth were recorded for each trap: the CW, CH, Ha and CC of all male crabs were measured; the CW and the AW of all female crabs were measured.

MAPPING AND ABUNDANCE ESTIMATION BY KRIGING

Kriging (Matheron, 1970; Clark, 1979) was used to estimate the biomass and map the local density of different crab categories (Conan, 1985; Conan et al., 1988; Conan et al., 1994) from the trawl and video camera survey data. A kriging program (MPOGEOS) (Surette et al., in press), developed specifically for estimating the snow crab stock in the southern Gulf of St. Lawrence, was used (Hébert et al., 2003). Kriging consists of two steps: (1) analyzing and modelling the empirical covariance between sampling units as a function of distance using

a theoretical covariance function; and then (2) estimating the densities of crab in non-sampled areas as linear combinations of neighbouring samples using the covariance function to assign weights. Distribution maps showing density contours were generated using point kriging. Block kriging was used to estimate the mean density and variance over specific areas and integrated to determine the total abundance in those areas.

Abundance estimates were converted to biomass using size-frequency histograms obtained from the trawl survey and a CW (mm) - weight (g) relationship, $W = 1.543 \times 10^{-4} CW^{3.206}$, previously determined for ENS snow crab (Biron et al., 1999). To be comparable with the video camera survey, the crabs from the trawl survey were categorized into commercial-sized males ≥ 95 mm CW, undersized males and females between 36 and 94 mm CW and immature crabs ≤ 35 mm CW.

3.0 RESULTS

TRAWL SAMPLING

There were 144 females and 276 males collected during the trawl survey in the GBH, of which 70 females and 74 males were immature; 71 females, 71 undersized males, and 18 commercial-sized males were adolescents; 3 females, 22 undersized males, and 89 commercial-sized males were adults. The area sampled during the trawl survey in the GBH was 3,388 km^2. The total biomass index of commercial-sized males from the trawl survey data for the sampled area was estimated at 2,527 mt [1,395 – 4,237 mt], and was comprised of 9% of soft-shelled crab and 91% of hard-shelled crab. The mean density was estimated at 1,927 crabs/km^2 for immature, 1,793 crabs/km^2 for undersized crabs and 1,298 crabs/km^2 for commercial-sized males.

Contour maps of the density distribution from the trawl survey data illustrated that commercial-sized crabs were mostly distributed east of St. Ann's Bank, while lower concentrations were observed on the slopes west of the GBH (Fig. 5). The high-density concentrations that projected east of St. Ann's Bank were predominately due to one trawl station with a very high density, while the immediate surrounding stations had very little commercial-sized crabs. Similar distributions were observed for immature and undersized crabs, although the concentrations observed around the GBH were located more toward the southwest on Smokey Bank (Fig. 5).

VIDEO CAMERA SURVEY

The reliability of the observations from the video camera varied depending on the type of bottom being surveyed. For example, immature and undersized snow crabs could easily be identified and counted on soft muddy bottom, even when half buried, because of the steadiness of the camera being dragged on this uniform bottom. The camera was also relatively stable on gravel and rocky bottom, but immature and 'smaller' undersized (i.e. ≤ 60 mm CW) snow crabs were much more difficult to spot because of similar sized pebbles in the surrounding area. Unidentified crabs were not counted. Overall, there were 37 crabs ≤ 35 mm CW and 15 crabs between 36 and 94 mm CW that could not be

distinguished between toad (*Hyas araneus* and *H. coarctatus*), rock (*Cancer irroratus*) or snow crab, although most were on grounds where only toad crabs had been observed. On shallower grounds, sections of some transects had algae growth that may have hidden some crabs from the camera's view. However, commercial-sized snow crabs were identified with confidence on muddy, gravel and rocky bottoms. It was only in rare cases of extremely rugged bottom that commercial-sized snow crabs may have avoided detection, either being concealed by boulders or missed when the path of the sled was rapidly altered after hitting an obstacle.

The area sampled by the video survey was 2,366 km^2. Five of the video survey stations were also sampled by the trawl survey. There were 485 snow crab identified during the video camera survey, 331 immature crabs, 59 undersized, and 95 commercial-sized male crabs. By using the mean weight of 578.8 g estimated from the trawl survey for adult crabs ≥ 95 mm CW, the total biomass index from the video camera survey was estimated at 2,882 mt [1,908 – 4,190 mt]. The mean density was estimated at 8,783 crabs/km^2 for immature, 1,503 crabs/km^2 for undersized crabs and 2,105 crabs/km^2 for commercial-sized males.

The majority of immature crabs observed during the survey were concentrated on the slopes and muddy bottom of the GBH (Fig. 6). The highest densities of undersized and commercial-sized crabs were mostly distributed along the slopes and the hard edges on either side of Smokey Bank (Fig. 6).

COMPARISON BETWEEN TRAWL AND VIDEO CAMERA SURVEYS

The trawl and video camera surveys shared a common surveyed area with a kriging surface of 1,406 km^2. The total biomass index of commercial-sized males in the common area was estimated at 1,083 mt [378 – 2,056 mt] for the trawl survey, and at 2,080 mt [1,438 – 2,917 mt] for the video camera survey. The mean density from the trawl survey in the common surveyed area was estimated at 1,330 crabs/km^2 for immature crabs, 1,806 crabs/km^2 for undersized crabs and 1,332 crabs/km^2 for commercial-sized males, while for the video camera survey these were 12,157 crabs/km^2 for immature, 1,647 crabs/km^2 for undersized and 2,556 crabs/km^2 for commercial-sized males. A comparison factor (CF) was derived from these results as CF = video survey / trawl survey. The immature CF was 9.14, while the undersized and commercial-sized CFs were 1.10 and 1.92, respectively.

TRAP SURVEY

The 16 modified conical traps sampled during the trap survey captured a total of 488 snow crab. No immature and no female crabs were caught in the traps. A large proportion of the sampled crabs (29%) were undersized, and was comprised of 11% adolescent males (n=16) and 89% of adult males (n=127). The remaining crabs caught were commercial-sized males, and were comprised of 5% adolescents (n=17) and 95% adults (N=328). Only 1 soft-shelled adult was captured.

4.0 DISCUSSION

As previously mentioned, the GBH experiment was not designed to compare the video camera with the *Nephrops* trawl, but rather to complement it by surveying the hard non-trawlable grounds encountered within the surveyed areas. However, the application of both methodologies led to some interesting comparisons and underlined some of the advantages and disadvantages of the two techniques. The camera sled used in this study was simple to operate and proved to be an effective means of surveying commercial snow crabs and their habitats. As in other studies (e.g. Conan and Maynard, 1987; Spencer et al., 2005; Morrison and Carbines, 2006), the camera sled caused little damage to substrate, mobile organisms and sessile invertebrates. Practical advantages were the accuracy of quantification made possible by replaying the video recordings, the superior performance of a towed system over non-trawlable bottom, the unrestricted tow duration, and the collection of habitat information along with the quantification of a variety of other species (e.g. toad crab, anemone, sponge, brittle star, sea star, mud star, sun star, basket star, sea cucumber, sea potato, urchin, flat fish, sand dollars). Partially buried snow crabs were observed while surveying areas with soft bottoms, confirming observations originally reported by Miller (1975). The integration of GPS data in the video recording may be of future use in the modelling of the spatial distribution using fine-scale habitat information and associated species assemblages not available in conventional surveys (Spencer et al., 2005; Morrison and Carbines, 2006). During the course of this study, the performance of the camera sled was observed over a variety of habitat types (i.e. sand, mud, gravel, rocky, high-relief and rough bottom), and although it performed best on low-relief soft bottom, it was also manœuvrable over extremely rugged bottom and still produced valuable results, particularly for the commercial-sized crabs. The limitations in the video camera method included: the potential for organism density saturation within the viewing area (e.g. brittle stars); limitations in certain habitats (e.g. algae covered grounds); a narrow width covered (i.e. 1.2 m); and the inability to conclusively establish the sex of crabs ≤ 95 mm CW, the maturity stage or the carapace condition of the viewed animals.

Converting video images into hard data proved to be very time consuming. The video speed had to be slowed to 1/4 and 3/4 of the normal speed to be able to see all the details, including movement; sometimes had to be repeated to properly identify the crabs; and had to be stopped to measure the crabs. Overall, the ratio was 10 hours of work to convert 1 hour of video into hard data, excluding the survey itself, data entry and analysis.

Conversely, the *Nephrops* trawl samples a larger spatial area per tow; it is a proven sampling technique which retains all captured specimens, hence allowing for direct measurement (e.g. sex, CW, CH, Ha and CC); stock abundance estimates can be used to forecast recruitment to the fishery (Surette and Wade, 2006); and capturing (measuring) precise data is less time consuming. As with the video survey, the integration of GPS information permits the modeling of the spatial distribution. The limitations of the *Nephrops* trawl

include: impediments on certain bottom types (e.g. hard gravel bottoms and rough bottoms) and distance over which it can be conducted; no direct observations on the habitat characteristics, other than from by-catch information; it may cause damage to the sampled habitats; and unknown catchability and/or selectivity over different bottom types. The last point was obvious in the common surveyed area (mainly hard bottom) where twice as many commercial-sized crabs and nine times more immature crabs were estimated from the video survey than the trawl survey. The catchability of the *Nephrops* trawl over soft bottom is assumed to approach 100% for crabs over 35 mm CW, while the selectivity for crab under 35 mm CW is known to be poor (Moriyasu et al., 1998).

At the time of the trawl and video camera surveys from the end of June to the beginning of July 2003, the highest local densities of adult crabs ≥ 95 mm CW was located on the hard bottom immediately surrounding the GBH area. Although some of these hard grounds were covered by the trawl survey, parts of Smokey Bank, judged non-trawlable because of rocky bottoms, were also harbouring medium to high densities of commercial crab (i.e. 1000-4000 crabs/km^2). The distribution of snow crab over these grounds should not be surprising considering that the coldest recorded bottom temperatures during the surveys were found on Smokey Bank (-0.5 to 0.75°C).

This study supports previous researches, which theorize that the boundaries of snow crab distribution are mainly a function of temperature (Slizkin, 1982; Drinkwater et al., 2003). Furthermore, recent investigations suggested that coastal populations of snow crab in the Gulf of St. Lawrence move extensively during the spring and winter and are not restricted to their deep-water summer habitat (Taylor et al. 1985, Sainte-Marie et al. 1988, Comeau et al. 1991, Sainte-Marie and Hazel 1992, Lovrich et al. 1995). It has been proposed that seasonal movements towards shallower, colder water in the winter and early spring are linked to moulting (Sainte-Marie and Hazel 1992, Lovrich et al. 1995, Comeau et al., 1998) and breeding (Hooper, 1986; Brêthes and Coulombe, 1989; Comeau et al., 1998).

The apparent inaccuracy of the annual trawl survey in this relatively small area may have been caused by a combination of the uncounted crab located in the non-trawlable perimeter of the traditional surveyed area, and by the lower catchability of the trawl over the harder ground of the surveyed area. In 2003, for example, the conventional trawl survey estimated the total biomass of commercial-sized crabs to be about 2,500 t. However, if we accept the total biomass estimated from the video camera survey, which was more accurate on hard bottom based on the direct observations of crabs, than we can infer that the total biomass should be equal to the total biomass from trawl survey minus the trawl survey biomass from common area plus the total biomass from video camera survey (2,527 mt – 1,077 mt + 2,882 mt = 4,332 mt). This results in an increase of over 40% relative to trawl survey estimate alone. The information collected here demonstrates that by using a video camera survey over hard bottom to complement the *Nephrops* trawl conducted mainly over soft bottom, it is possible to effectively measure the abundance of commercial-sized snow crab.

However, differences in selectivity between gear types must be

understood before interpreting results in such a manner. For example, a trawl will not select crab based on CC, but a trap will by catching very little crab of CC-1 and CC-5. In the same manner, immature are easily observed with the video camera but the trawl and trap selectivity from this category is poor. Therefore any conclusions made from the observed differences in soft-shelled and immature crabs between the trawl, video camera and trap surveys are meaningless. Gear selection is one of the most important steps in planning a study and must be appropriate for the target species and habitats as well as for the overall objectives of the study (Rozas and Minello, 1997). In the case of the GBH, which is comprised of a mixture of trawlable and non-trawlable bottom, the best strategy for a survey of snow crab may be a combination of the conventional *Nephrops* trawl, video camera and trap surveys to improve and increase the coverage of the stock assessment.

The concentration of crab located on hard ground just outside the GBH also hints at the importance of timing for this fishery, which begins at the end of July. Anecdotal evidence from groundfish trawlers showed a lack of large commercial crab concentrations on hard ground one to two weeks prior to the snow crab fishery (Biron et al., 2004). Snow crabs are believed to synchronize their inshore migrations with temperature in order to experience a stable thermal environment conducive to sustained locomotive (i.e. metabolic) activity (Lovrich et al. 1995). Other studies have shown that the occupation of snow crab on shallow grounds from October to May might be temperature dependent, as it would be energetically costly for snow crab to reside in the warmer, shallow areas during summer (Maynard 1991, Lovrich et al. 1995). In the case of the GBH, bottom temperatures were still slightly colder on the banks at the end of June – beginning July than on the deeper main fishing grounds. An earlier fishery would probably not be able to exploit the traditional fishing grounds to the same extent due to a possible lack of large abundances of commercial-sized crabs.

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6.0 FIGURES

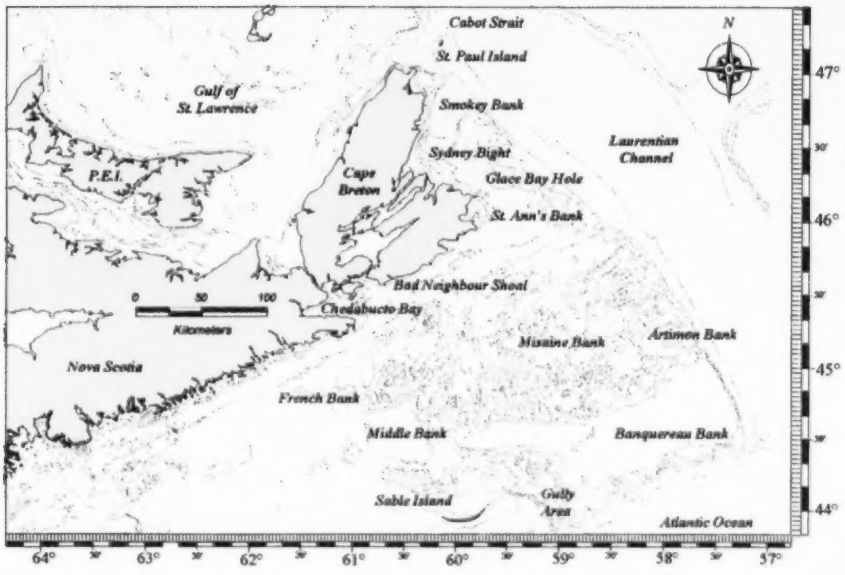

Figure 1. The areas and locations of eastern Nova Scotia.

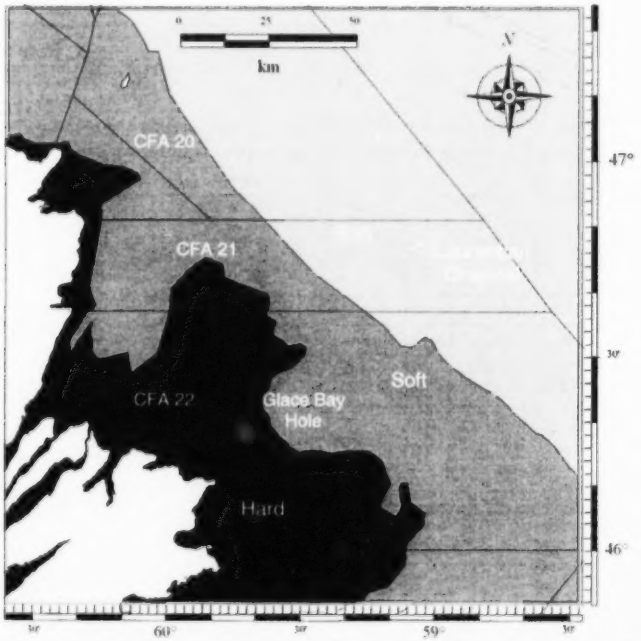

Figure 2. The snow crab management areas (CFA 20 to 22) in Sydney Bight with bottom types (■ hard/cold, □ soft/cold, and □ soft/warm).

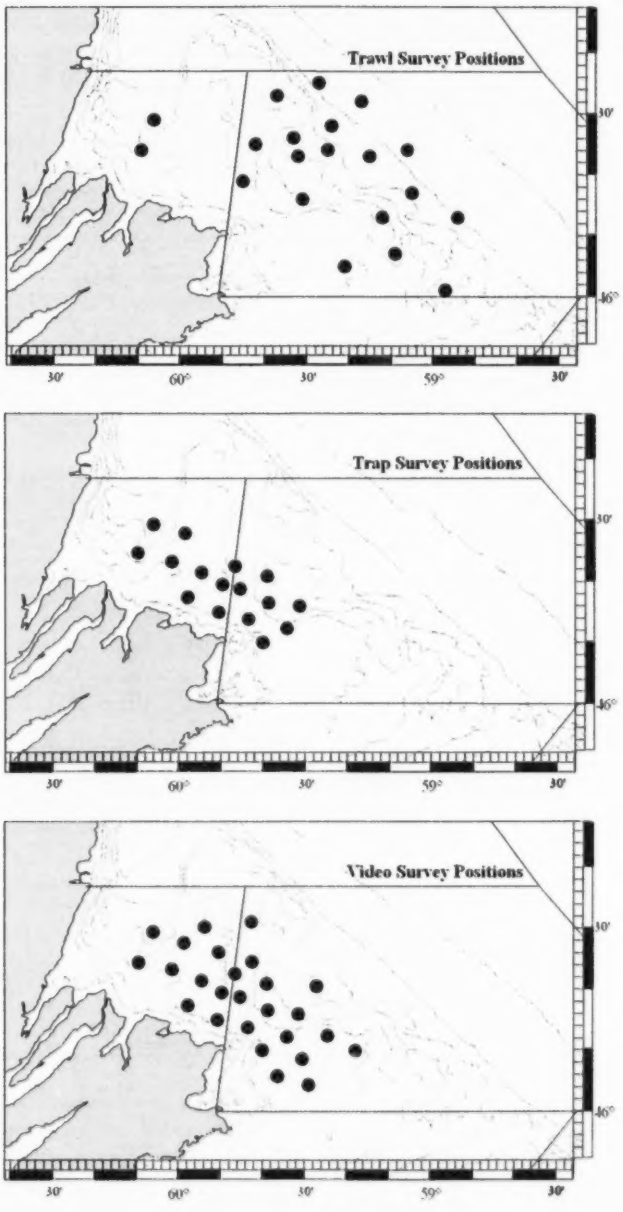

Figure 3. Location of snow crab trawl, trap and video survey stations for the Glace Bay Hole (GBH) experiment in 2003.

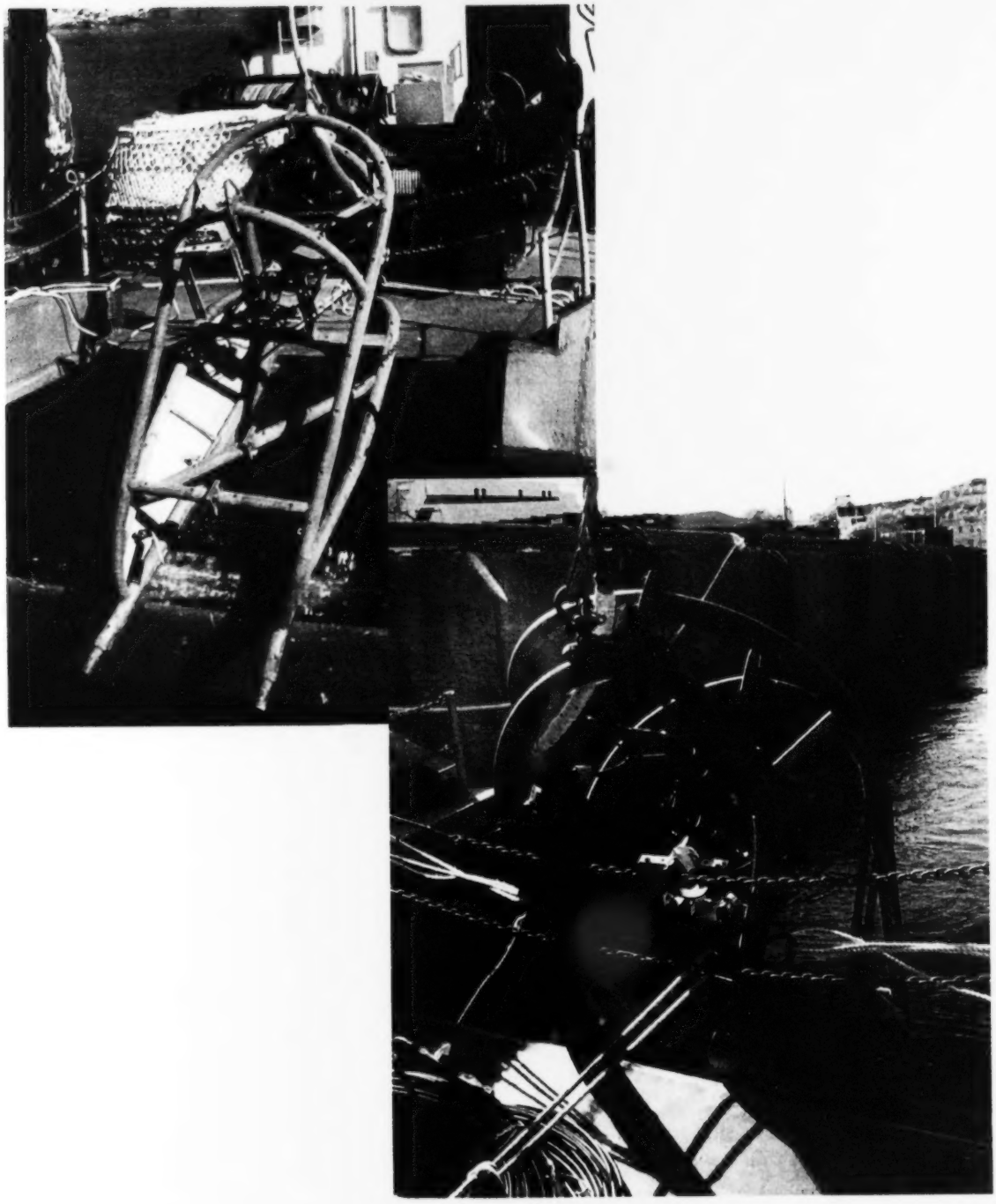

Figure 4. The video camera and sled.

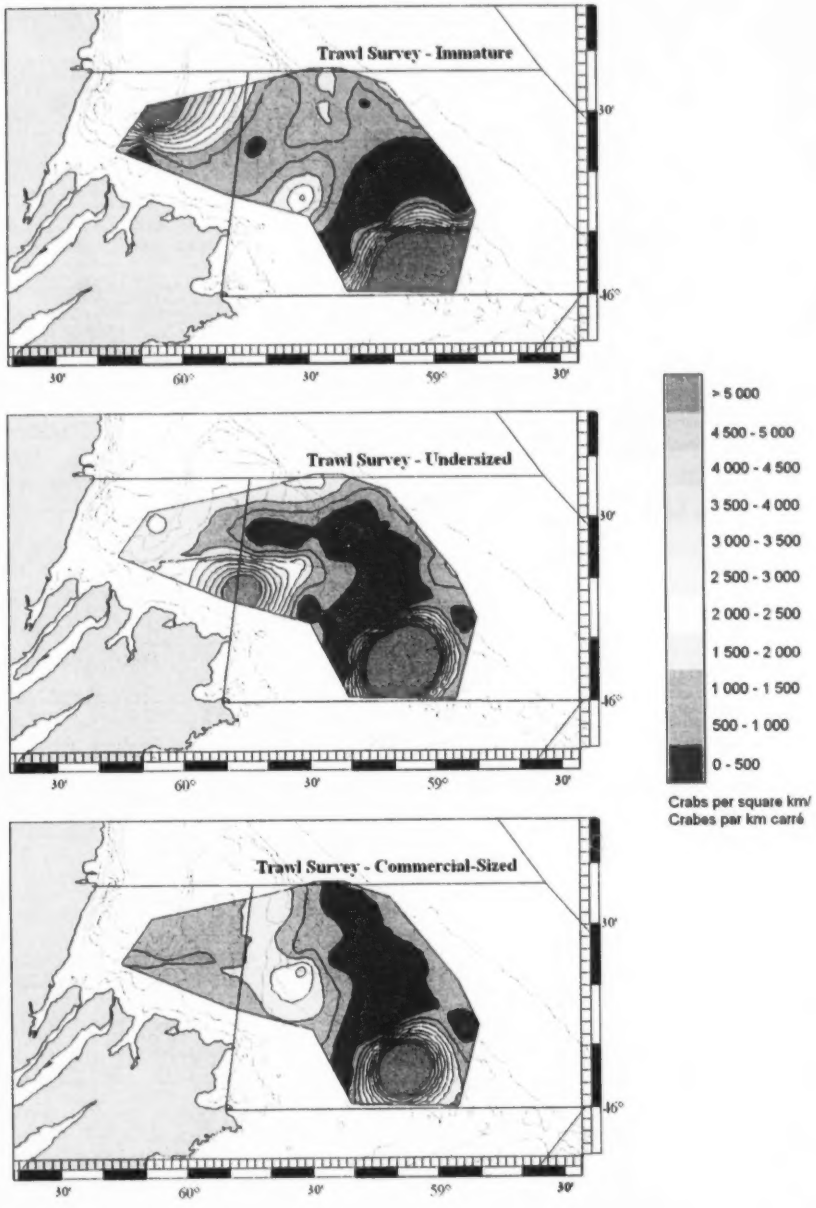

Figure 5. Estimated snow crab distribution in the study area based on the trawl survey data.

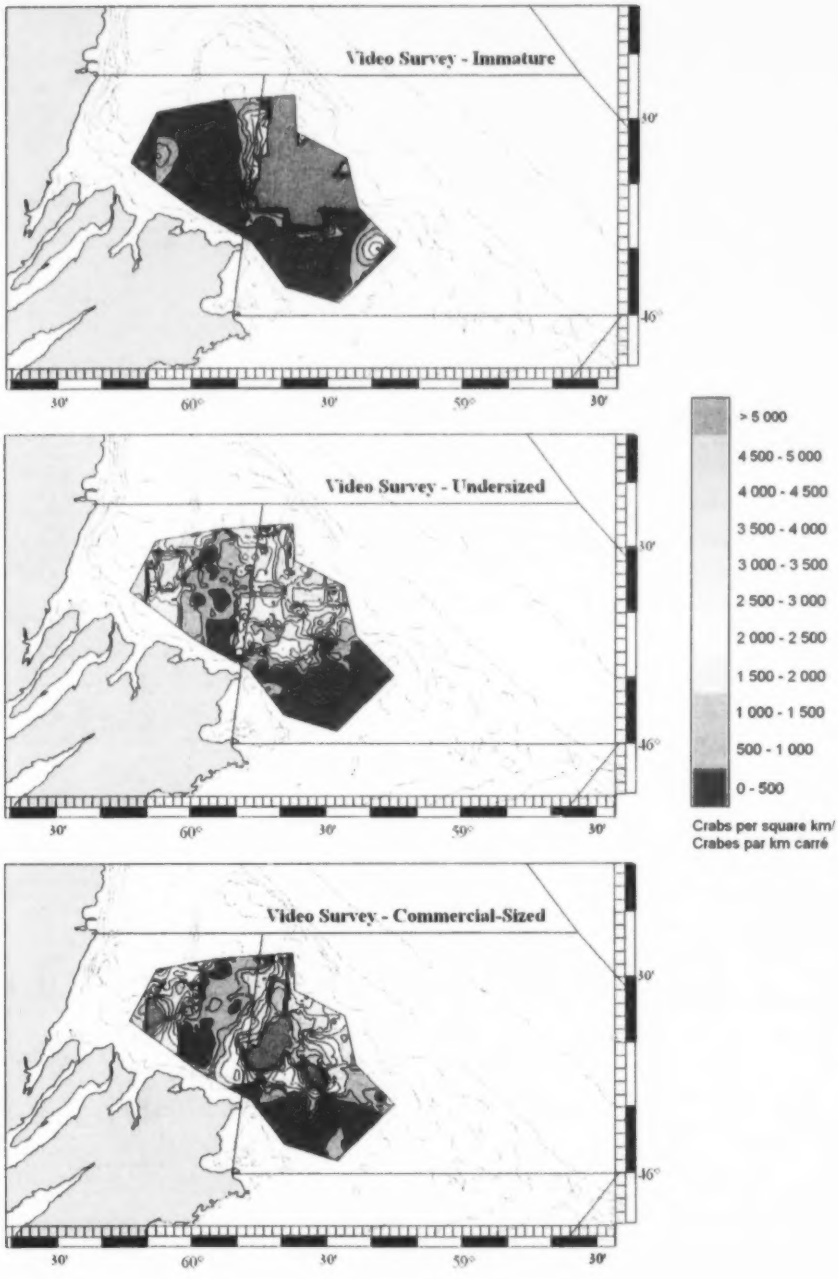

Figure 6. Snow crab distribution in the study area based on the video camera survey data.